

(11) (A) No. 1,105,093

(45) ISSUED 810714

(English Equivalent of

(52) CLASS 327-1.1
C.R. CL. 117-61

EP 0002738)

²
(51) INT. CL. H05B 9/00

(19) (CA) **CANADIAN PATENT** (12)

(54) LASER DEPOSITION OF METAL UPON TRANSPARENT MATERIALS

(72) Drew, Roland F.;
Schmidt, Frank J., Jr.;
VanGynhoven, Thomas J.,
U.S.A.

(73) Granted to International Business Machines Corporation
U.S.A.

(21) APPLICATION No. 310,046

(22) FILED 780025

(30) PRIORITY DATE U.S.A. (862,797) 771221

NO. OF CLAIMS 5

OFFICIALIZED BY THE PATENT OFFICE, OTTAWA.
CCA-274 (2-82)

15

Background of the Invention

16 Field of the Invention

17 The present invention relates to a method of selectively
18 depositing metal or other materials upon a transparent or
19 translucent substrate. More particularly, the invention
20 relates to a method and apparatus adapted for utilizing a
21 laser beam to selectively deposit metal upon transparent
22 materials in desired patterns.

23

History of the Prior Art

24 Laser beams have been utilized in various applications
25 as light sources, and as machining devices in connection
26 with metal and/or softer materials. In particular, U. S.
27 Patent No. 4,000,492 describes a laser machining system
28 wherein a laser beam is utilized as a source of pulses of
29 coherent radiation directed to form discrete holes in a
30 metal material.

Other laser systems have been utilized in image recording techniques. For example, U. S. Patent No. 4,001,840 describes a digital laser used in recording and reading apparatus.

In addition to these diverse applications of laser technology U. S. Patent No. 3,560,258 to Brisman discloses a technique of depositing materials in patterns by use of laser radiation and IBM* Technical Disclosure Bulletin, Vol. 8, No. 2, July 1965 to Potts et al. discloses a technique of inducing evaporation of materials for deposition, utilizing a laser source.

The Potts device, in particular, contemplates a technique for forming interconnection patterns on a substrate by placing opposite the substrate a film of evaporizable materials disposed on a glass plate. A laser beam of energy scans the metallic film through the glass plate to selectively evaporate portions of the film which then deposit upon the semiconductor substrate in accordance with the desired pattern. The Brisman technique appears to be useful but it has certain limitations in manufacturing performance. For example, the thickness of the film must be carefully controlled in order to yield a desired thickness on the substrate, and the placement of the film with respect to the substrate is likewise critical. Since the film is not re-useable the method would be relatively expensive. Finally, the location of the deposited area on the substrate is difficult to control inasmuch as the film obscures the substrate and prevents any visual registration between the laser source and the substrate.

* Registered Trade Mark

FI-9-77-044

1 Accordingly, a need exists in the prior art for a
2 method of depositing material, selectively, upon a substrate
3 utilizing a laser source in a precise and well defined
4 fashion.

5 Summary of the Invention

6 The present invention contemplates a method and apparatus
7 for selectively depositing metal or other materials upon a
8 transparent substrate utilizing a laser source. More parti-
9 cularly, the invention contemplates depositing material in
10 highly selective areas with a high degree of adhesion and
11 uniformity.

12 The invention attains these results with an arrangement
13 wherein a laser source is located on one side of a transparent
14 or translucent substrate upon which metal is to be deposited,
15 so that the laser beam can be directed through the substrate.
16 A reservoir of metal is located on the opposite side of the
17 substrate adjacent to the surface thereof. Deflection means
18 are provided to selectively scan the laser beam at predetermined
19 intensity levels over a desired pattern.

20 The scanned laser beam acts to heat and vaporize metal
21 from the metal reservoir, which is then redeposited upon the
22 adjacent surface of the glass substrate. It has been found
23 that with transparent substrates, metal and particularly
24 conductive metal can be redeposited upon one surface thereof
25 using this method with a high degree of adhesion and uniformity.
26 The method has particular utility with respect to the repair
27 of masks utilized in semiconductor fabrication, for example.

1 Brief Description of the Drawings

2 The drawing is a schematic illustration of a laser beam
3 arranged in conjunction with a transparent substrate and a
4 metal reservoir to perform metal deposition.

5 Detailed Description of the Invention

6 Referring now to the drawing a preferred embodiment of
7 the invention is described including a laser device. The
8 laser device includes a source 12, a lens system 14 and
9 deflection means 16 which are illustrated in schematic
10 fashion. These elements are tended to represent conventional
11 laser components which are commercially available. Substrate
12 18 comprises a transparent element upon which material is to
13 be deposited from a material reservoir 20 also illustrated
14 in the figure. In the preferred embodiment a solid state
15 Nd³⁺:YAG laser is utilized, although other laser sources
16 could be utilized as well. It is contemplated that the
17 laser indicated have a wavelength in the order of 1.06
18 microns, and it should be apparent that the laser wavelength
19 would be matched to the transparency wavelength of substrate
20 18 illustrated in the figure.

21 In the embodiment illustrated substrate 18 is supported
22 along its edges by a suitable frame 22 and metal reservoir
23 20 is supported upon a base 24. In the embodiment illustrated
24 the spacing between the underside of substrate 18 and the
25 top of reservoir 20 is very small, i.e., in the order of a
26 few thousandths of an inch. It is possible, in an alternative
27 mode, to support the substrate on the metal reservoir in
28 direct contact therewith. Means can be provided to adjust

1 the spacing between substrate 18 and the top of reservoir
2 20, if desired. The spacing between the substrate and
3 reservoir is significant but need not be varied during the
4 deposition operations.

5 Reservoir 20 can be comprised of a slug of any metal
6 suitable for vapor deposition. In particular, it has been
7 found that copper, brass, chrome and aluminum are suitable
8 for laser deposition. In the preferred embodiment it is
9 envisioned that substrate 18 comprise a transparent sub-
10 strate such as a substrate upon which conductive metal
11 layers are to be deposited. For example, substrate 18 might
12 comprise a plate glass substrate. It is also possible that
13 substrate 18 could be a transparent or translucent substrate
14 upon which decorative layers of non-conductive metal are to
15 be deposited, if desired. It should be apparent that the
16 light absorption characteristics of the given substrate
17 material, as matched to the source frequency of the laser
18 employed constitute the limiting factor on the substrate
19 materials and deposition materials which can be utilized.

20 In practice the apparatus described is preferably
21 utilized to form selective deposition of metallic material,
22 such as copper, upon the lower edge of a plate glass substrate
23 by scanning the laser beam, under the control of deflection
24 means, along a desired preselected pattern. Since the laser
25 is directed through the glass, registration with a desired
26 pattern can be quite easily accomplished. The laser deflection
27 means is adjusted to vaporize metal at a suitable rate and
28 the vaporized metal redeposits upon the underside of the
29 substrate, providing good adhesion to the glass substrate
30 and excellent uniformity of thickness.

1 The parameters used in the process depend upon the type
2 of positioning system utilized to orient the laser with
3 respect to the substrate. It should be obvious that an X-Y
4 positioning system for the substrate could be utilized as
5 well, if desired. In addition, the type of laser can be
6 varied depending upon the type of metal to be deposited and
7 the transparent substrate material which it is desired to
8 deposit the metal upon.

9 It should also be apparent that materials other than
10 metal could be deposited, if desired. In particular, non-
11 metallic materials that are susceptible of vaporization can
12 be processed utilizing the described arrangement.

13 The present arrangement has particular utility for
14 fabrication of metallic lands upon solid substrates and,
15 therefore, is susceptible of fabricating conductors or
16 resistors upon such substrates. In addition, the method
17 described can be utilized in repairing metal masks such as
18 chrome masks deposited upon glass.

19 The method described has advantages over the prior art
20 in that it is extremely a simple way of fabricating metal
21 lands having uniform thickness and good adhesion. The use
22 of the laser beam through a transparent substrate provides
23 good registration with simple orientation apparatus; and the
24 use of a metal slug for a metal reservoir is preferable to
25 the use of thin film in that the metal slug can be reused.
26 Alternatively, the metal can be retained within a crucible
27 and maintained slightly above its melting point whereby
28 depressions are not formed in the reservoir surface and the
29 reservoir can be used for essentially continuous processing.

1 The following example discloses a preferred method of
2 practicing the invention;

3 Example I

4 Using a YAG laser with a wavelength of 1.06 microns a
5 layer of copper was deposited upon plate glass. The in-
6 strument configuration was similar to that illustrated in
7 the drawing with a quarter inch copper slug being oriented
8 adjacent to a 1/16th inch substrate of plate glass. The
9 laser was utilized at a pulse repetition rate of 3 kilo-
10 hertz, an average power rating of 2 watts, and a scanning
11 speed of 2 millimeters per second. The linewidth of de-
12 posited material using the above configuration was in the
13 order of 10 mils or less and a layer of copper of uniform
14 thickness and good adhesion was formed upon the plate glass.

JMT:adm

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of selectively depositing material upon a transparent substrate comprising the steps of placing the transparent substrate adjacent to a source of material to be deposited,

directing a beam of laser radiation through the transparent substrate to a surface of said source of material,

and selectively moving the laser beam whereby the material is evaporated and redeposited upon the substrate.

2. The method of claim 1 wherein said material is a conductive metal.

3. The method of claim 2 wherein said transparent substrate is glass and said metal is copper.

4. The method of claim 1 wherein said laser is scanned across the substrate at a speed of about 2 millimeters per second.

5. The method of claim 4 wherein said laser is powered at a level of about 2 watts, with a pulse repetition rate of about 3 kilohertz.

